ACT-Stitch: Complex Predictions from Simple Descriptions

Mike Matessa

Human Automation Integration Branch
Ames Research Center

ACT-Stitch

- **Goal:** To easily model the interleaving behavior of experts
- **Problem:** Current modeling frameworks with linear control structures make it hard to model interleaving behavior
- **Solution:** A new framework that compiles a simple description of CPM-GOMS actions into complex interleaving behavior in the ACT-R modeling architecture

Interleaving

- Interleaving is starting a part of a second task before finishing a first task
- It is found in
  - Dual-task experiments
  - Anticipatory eye movements of drivers
  - Parallel mousing, looking, and speaking of air traffic controllers

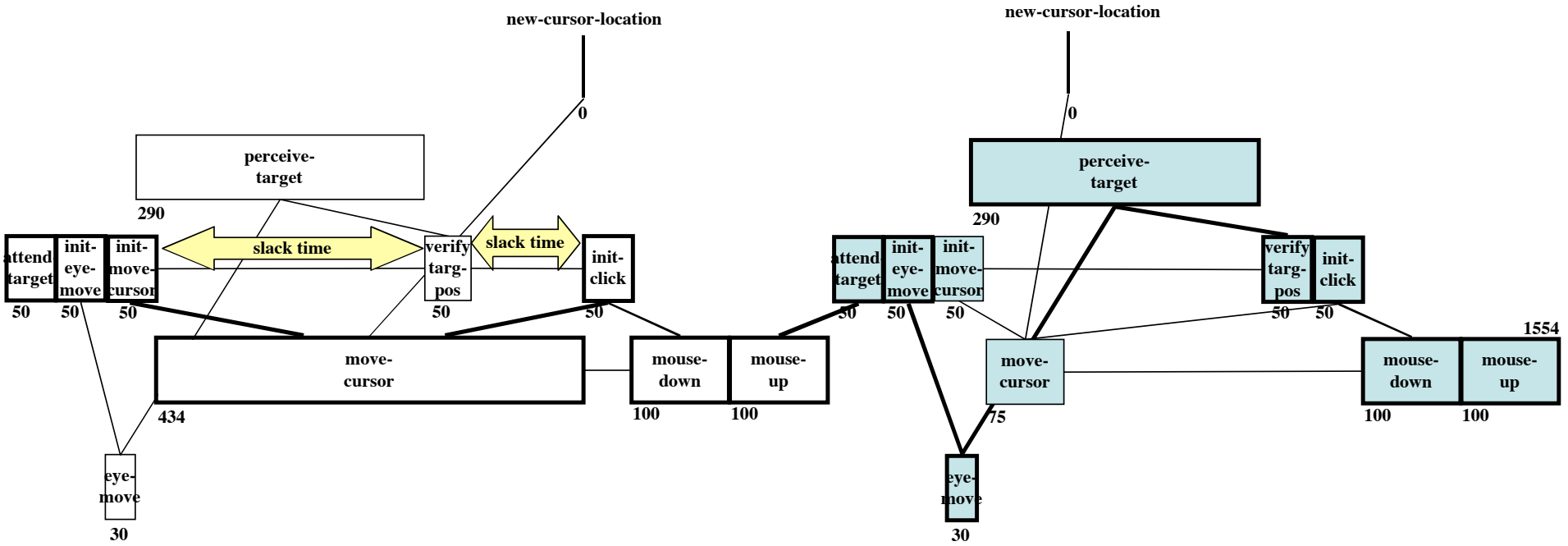
Why CPM-GOMS?

- It is one of the few real-life success stories of human performance modeling
  - Using CPM-GOMS, Project Ernestine made predictions that saved NYNEX millions of dollars
- CPM-GOMS templates already exist that can make zero-parameter predictions of skilled behavior
- The interleaving theory of CPM-GOMS has recently been codified (John, Vera, Matessa, Freed & Remington, 2002), allowing computational modeling in ACT-Stitch

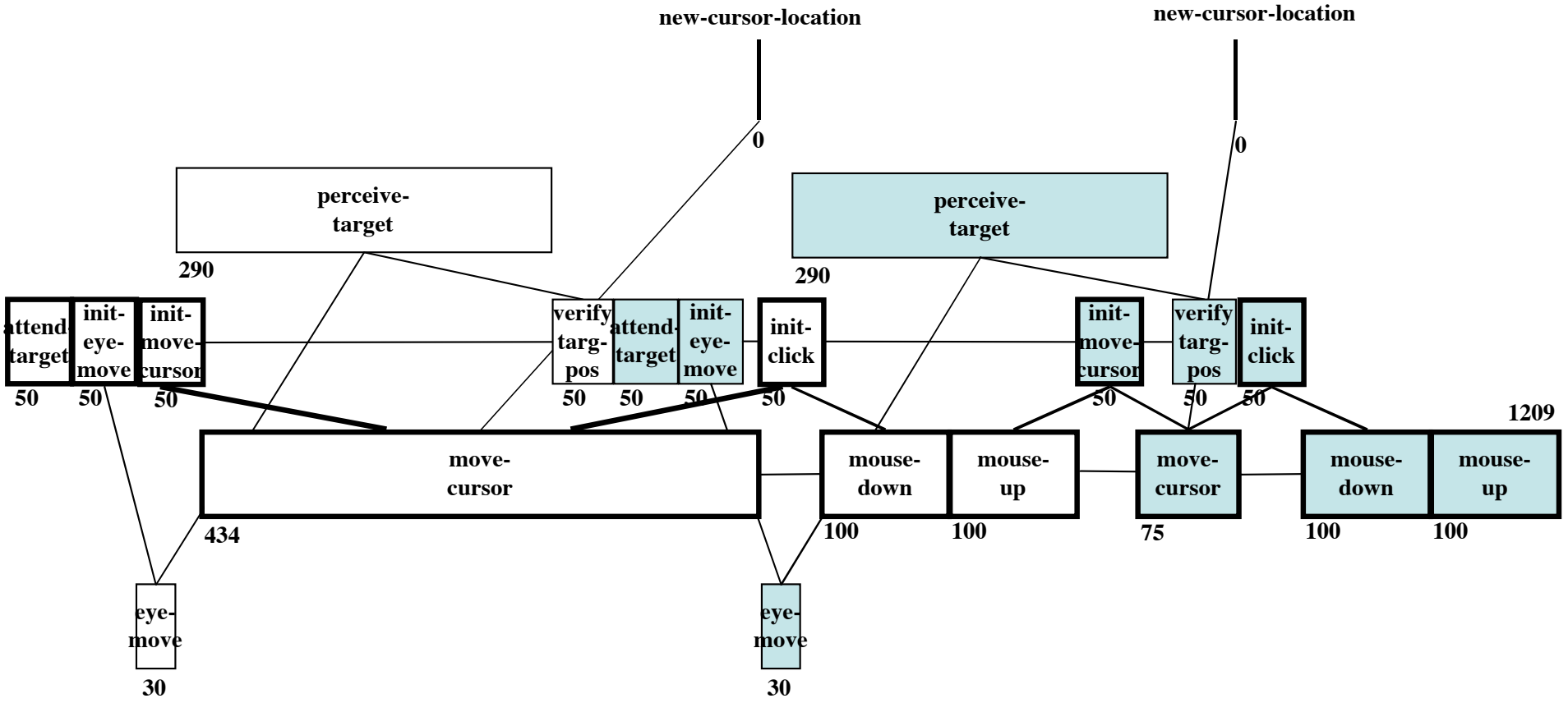
Why ACT-R?

- It is one of the most popular computational modeling architectures, allowing wide adaptation of ACT-Stitch
- While CPM-GOMS is a useful engineering approximation, ACT-R is a psychologically plausible theory of information flow and learning in human performance
- ACT-R has recently demonstrated learning of tasks from instruction taking all the way to skilled performance
  - A future goal is to incorporate the skilled performance of ACT-Stitch into a full learning model

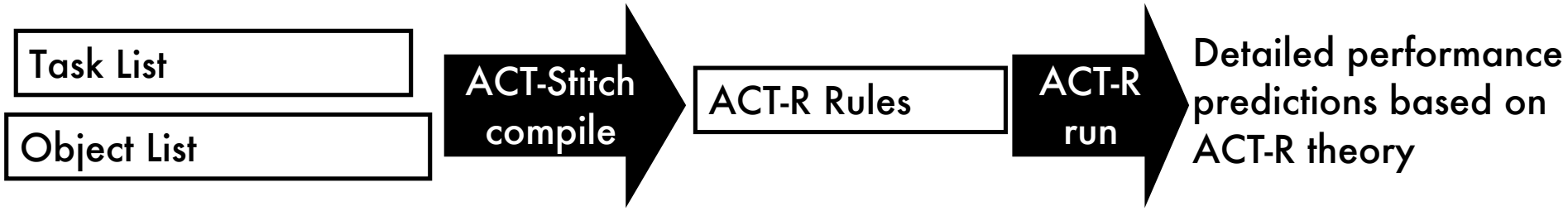
CPM-GOMS Templates



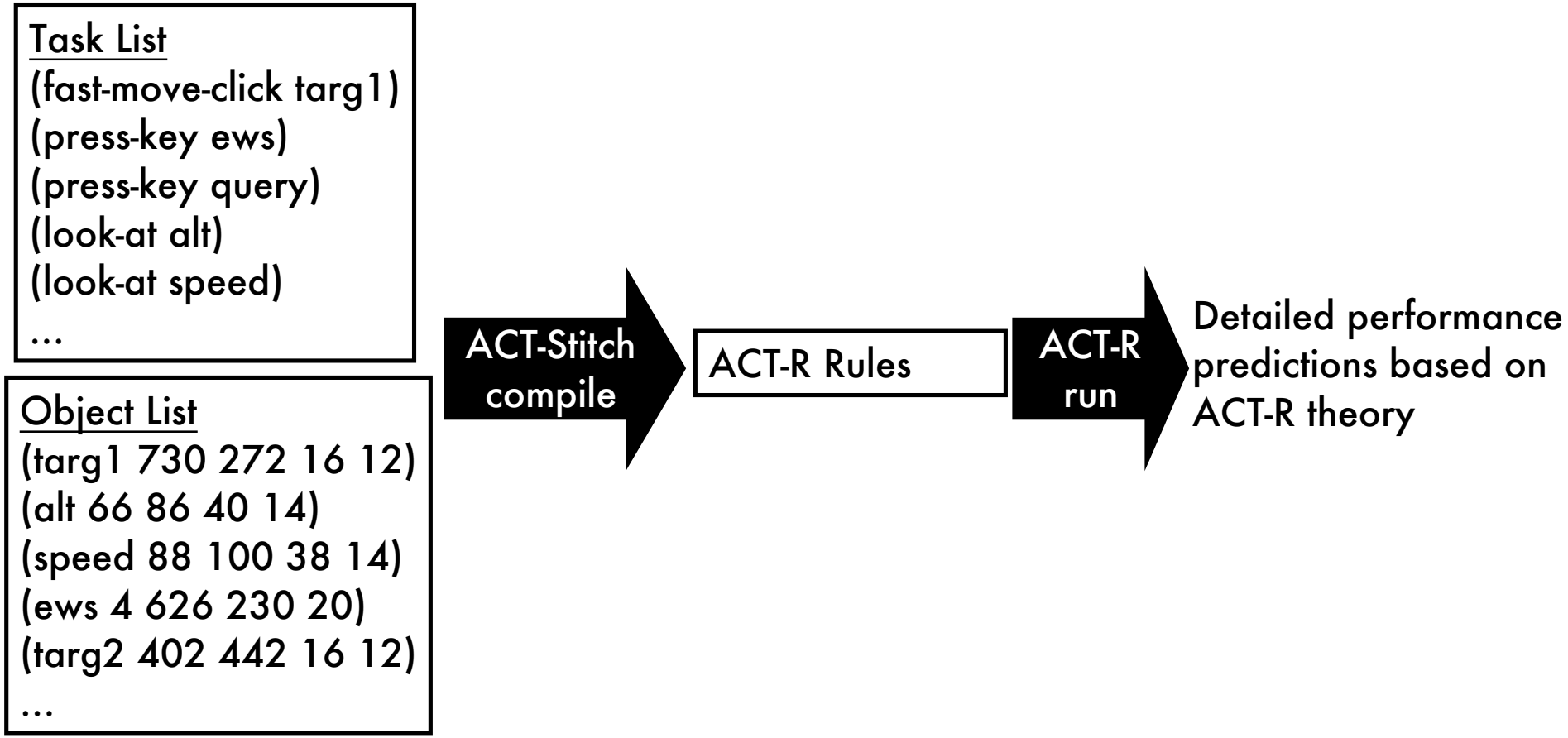
CPM-GOMS Interleaving



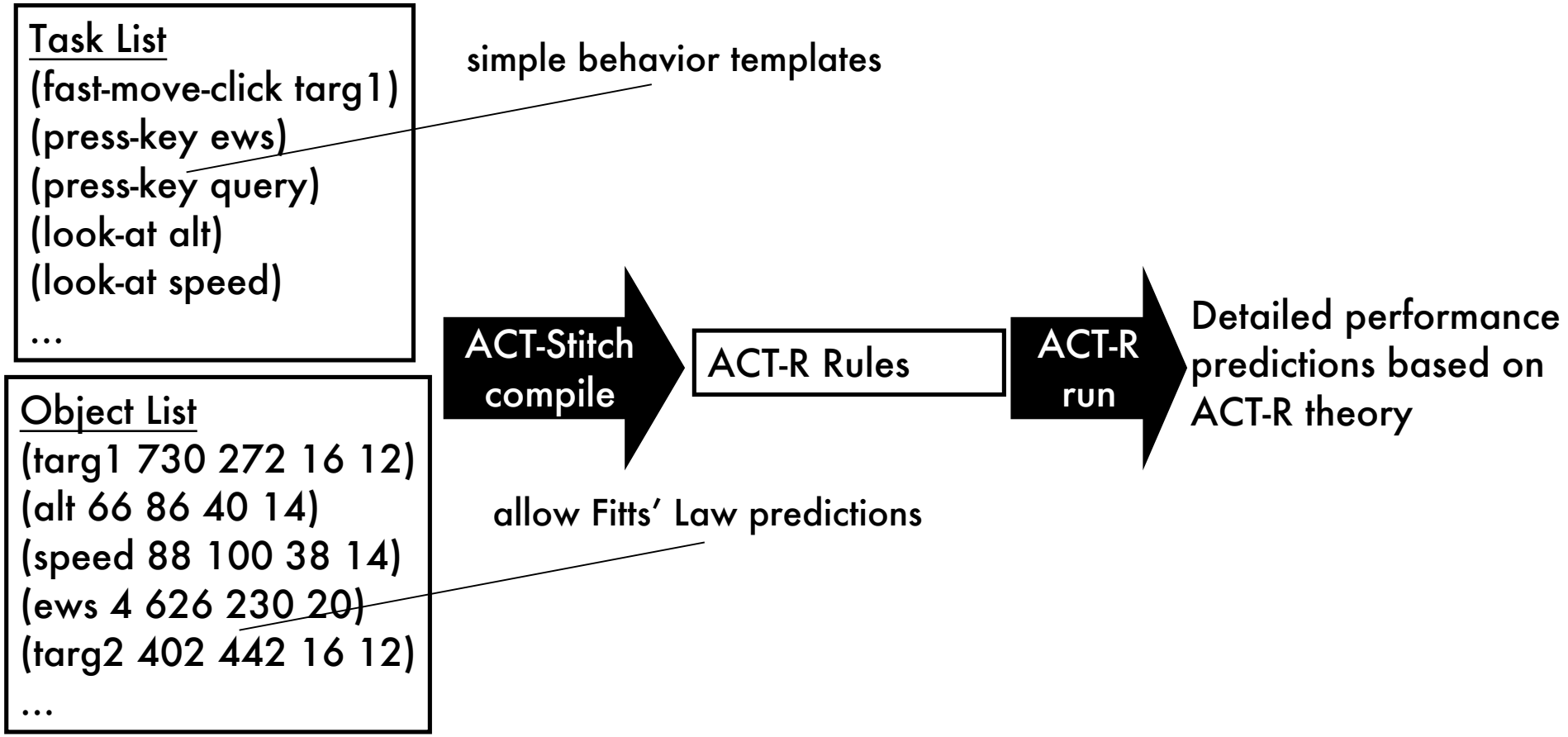
ACT-Stitch overview



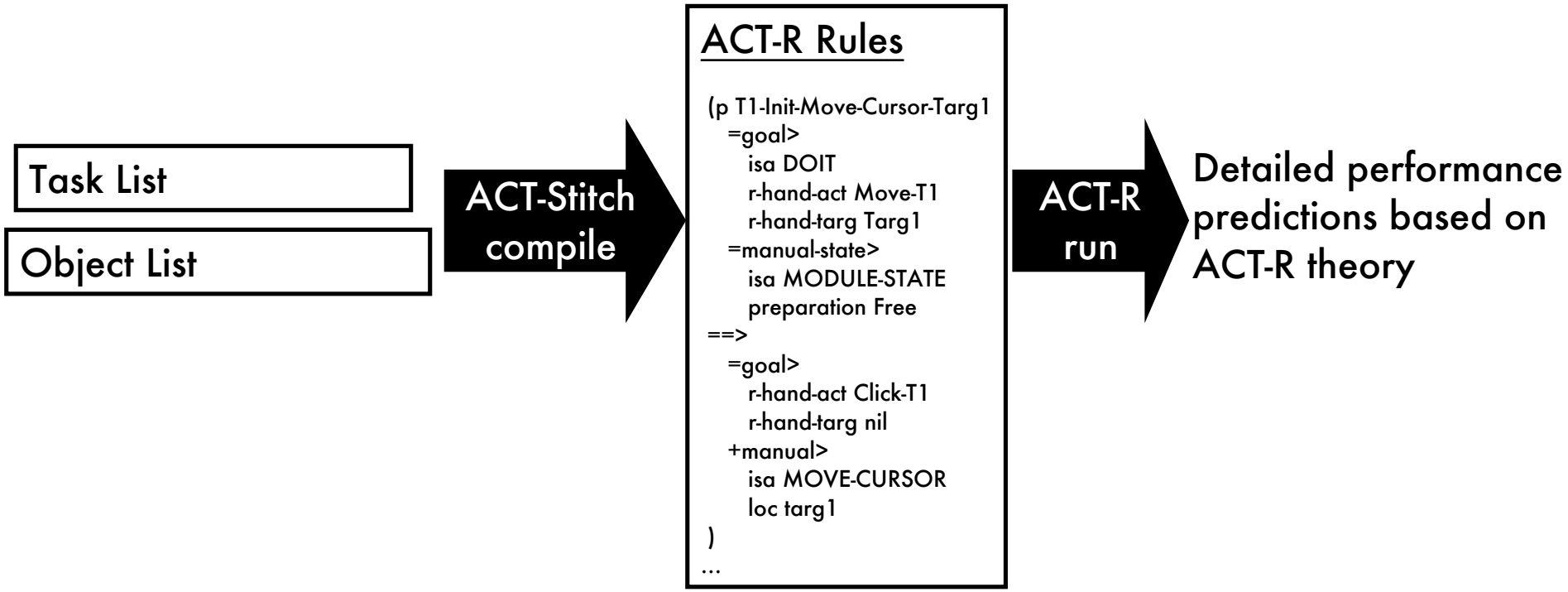
ACT-Stitch overview



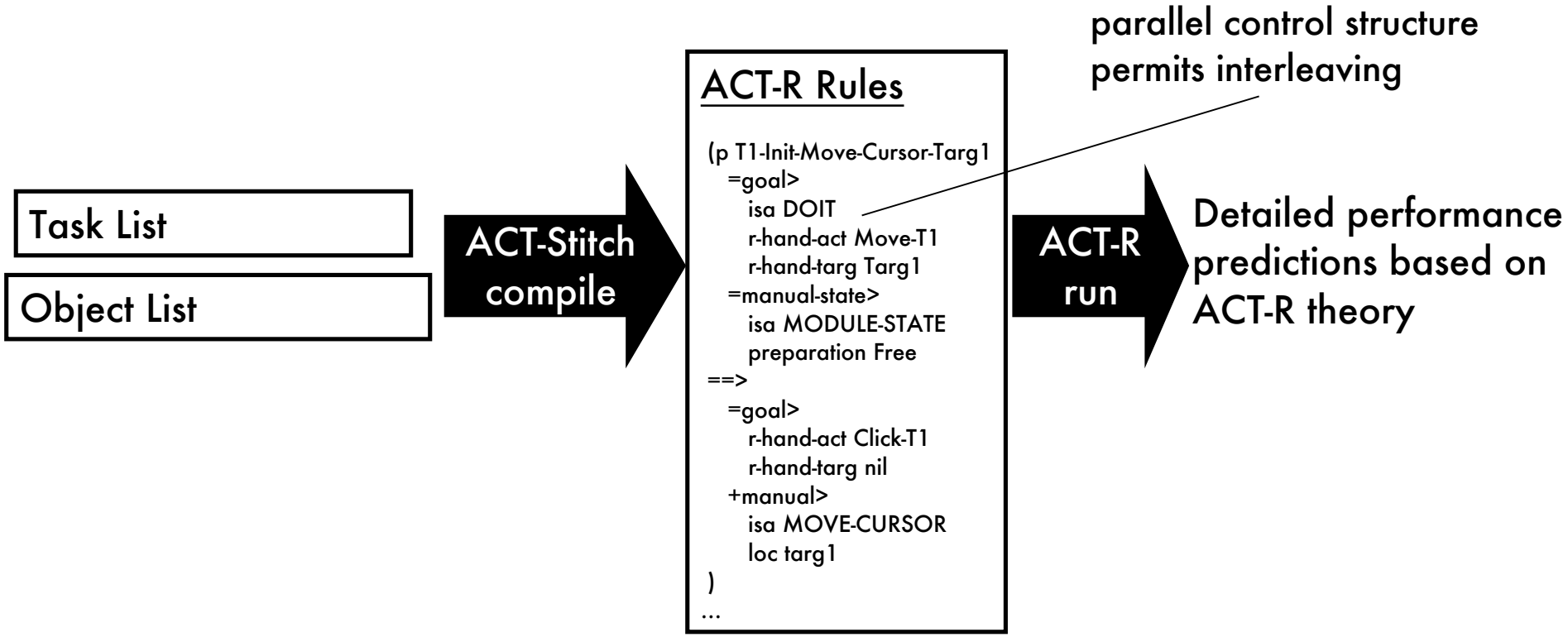
ACT-Stitch overview



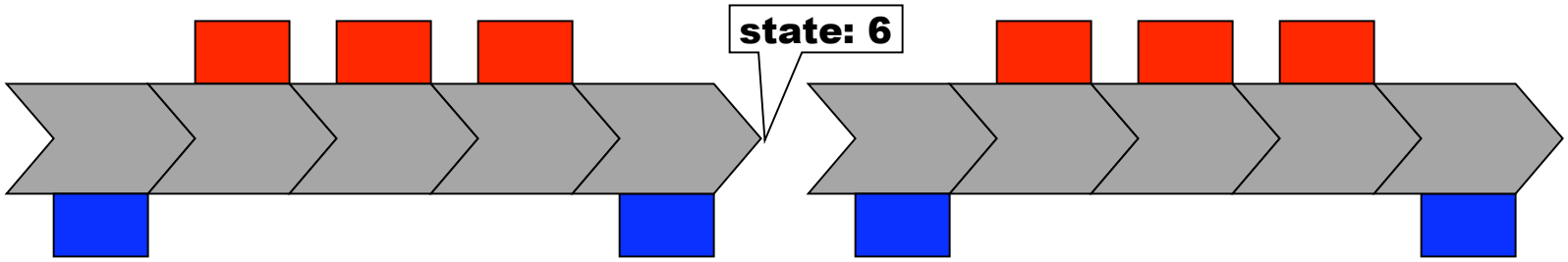
ACT-Stitch overview



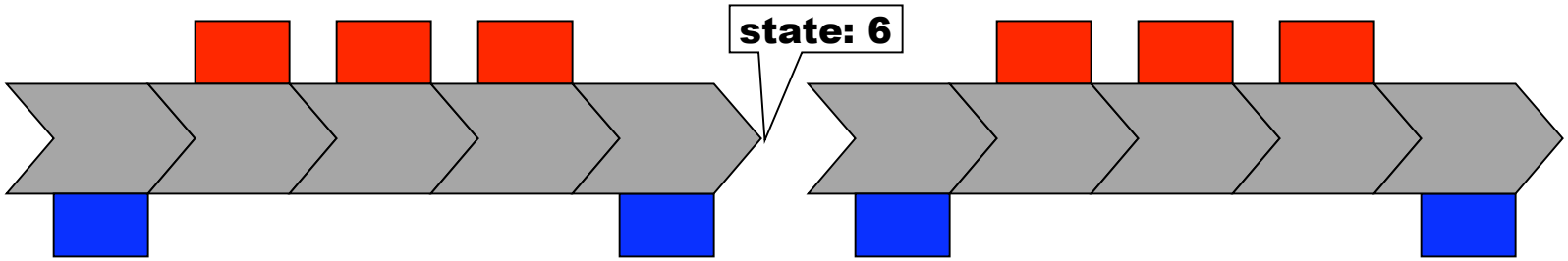
ACT-Stitch overview



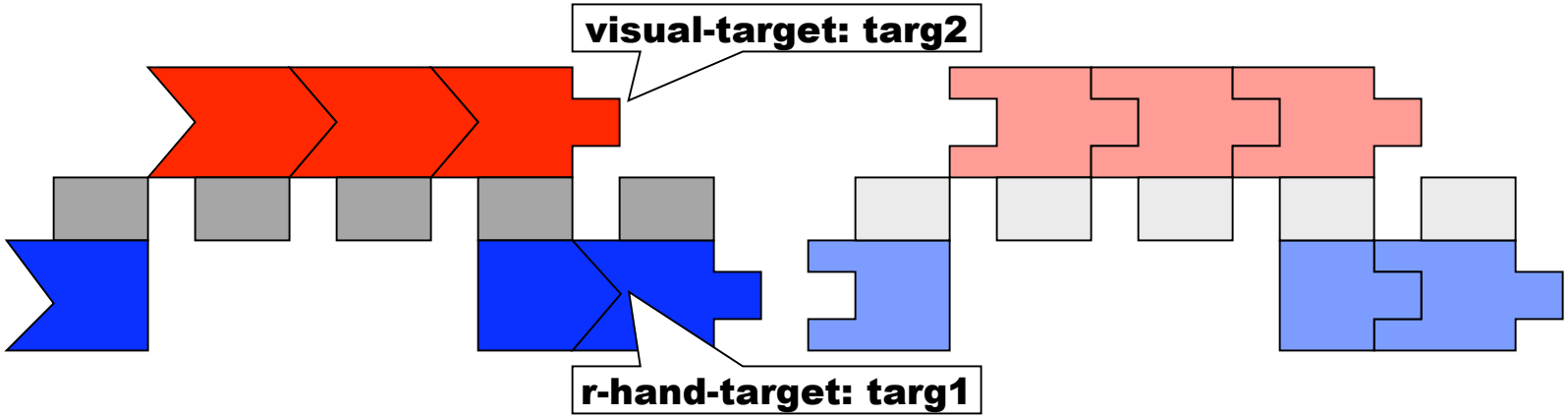
Current sequential ACT-R control structure:



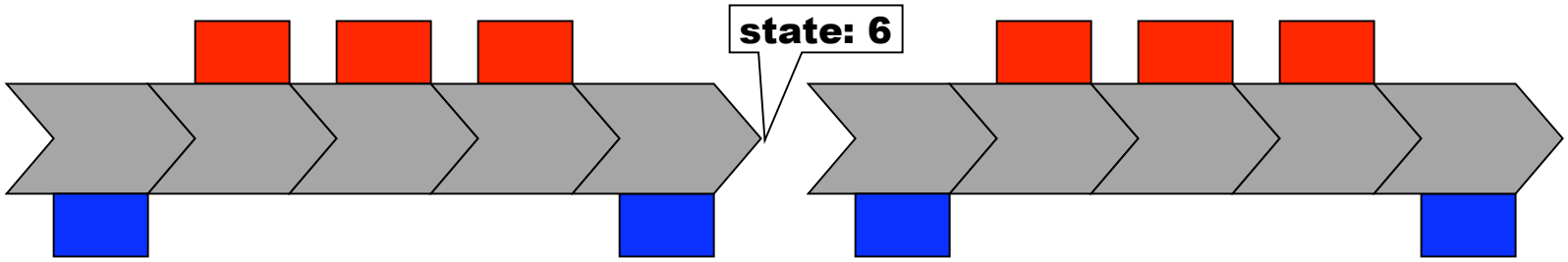
Current sequential ACT-R control structure:



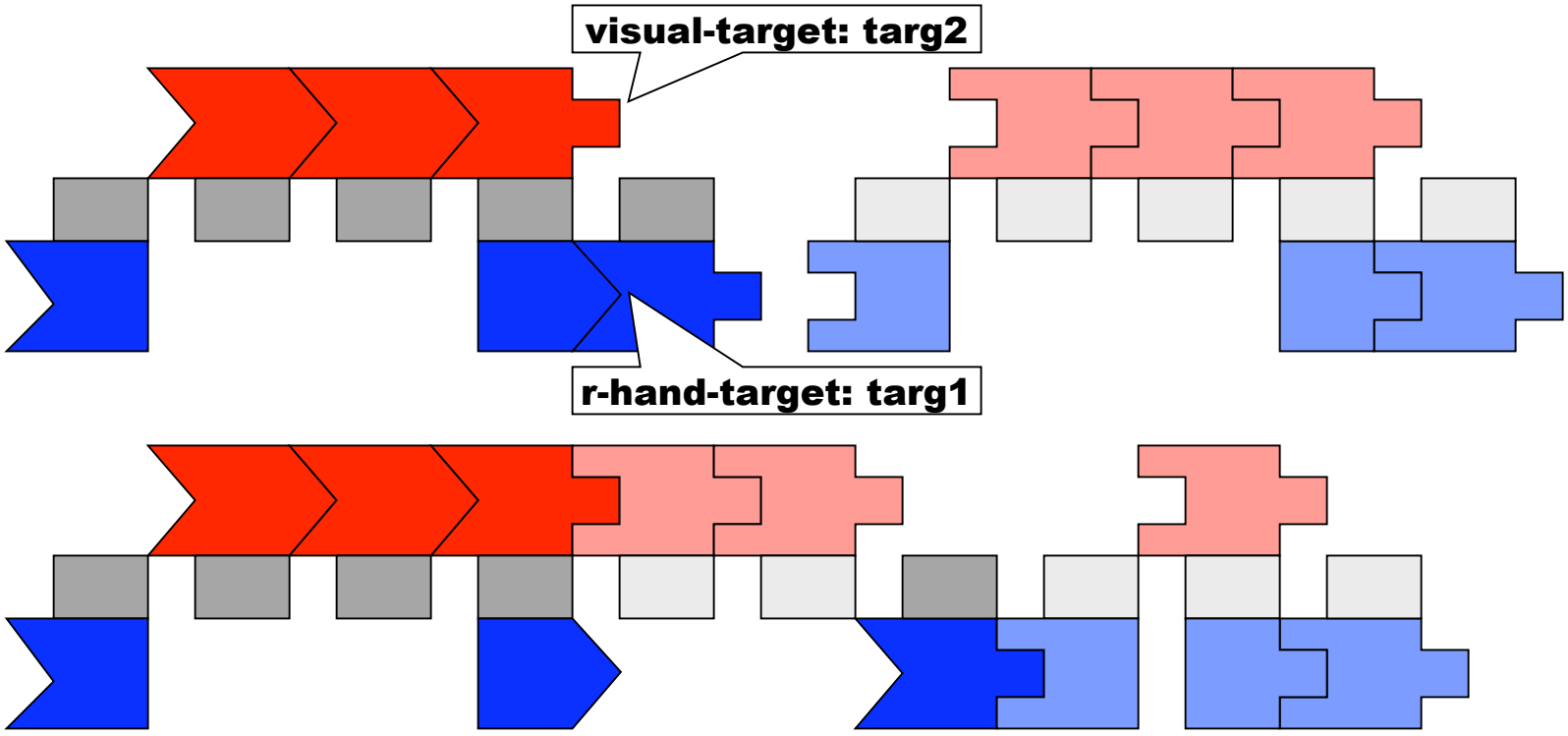
Parallel ACT-Stitch control structure:



Current sequential ACT-R control structure:



Parallel ACT-Stitch control structure:



Control Structures

Incorrect

state: T1

won't allow
interleaving

vision-target: targ2
r-hand-target: targ1

positional confusion
with double targets

Control Structures

Incorrect

state: T1	won't allow interleaving
vision-target: targ2 r-hand-target: targ1	positional confusion with double targets
vision-action: T2 r-hand-action: T1	single action only per template

Control Structures

Incorrect

state: T1	won't allow interleaving
vision-target: targ2 r-hand-target: targ1	positional confusion with double targets
vision-action: T2 r-hand-action: T1	single action only per template
vision-action: attend-T2 r-hand-action: click-T1	single target only per template

Control Structures

Incorrect

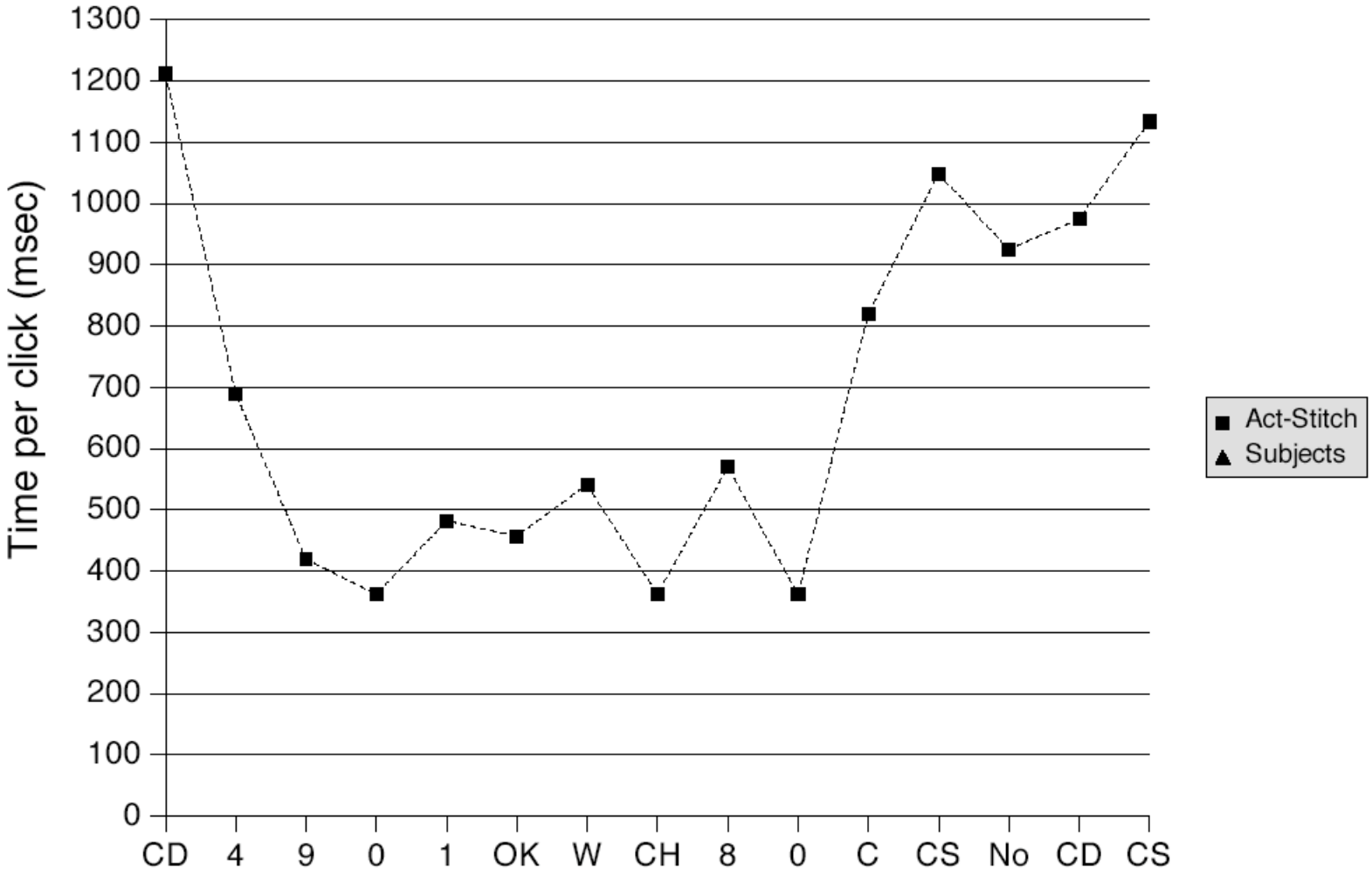
state: T1	won't allow interleaving
vision-target: targ2 r-hand-target: targ1	positional confusion with double targets
vision-action: T2 r-hand-action: T1	single action only per template
vision-action: attend-T2 r-hand-action: click-T1	single target only per template

Correct

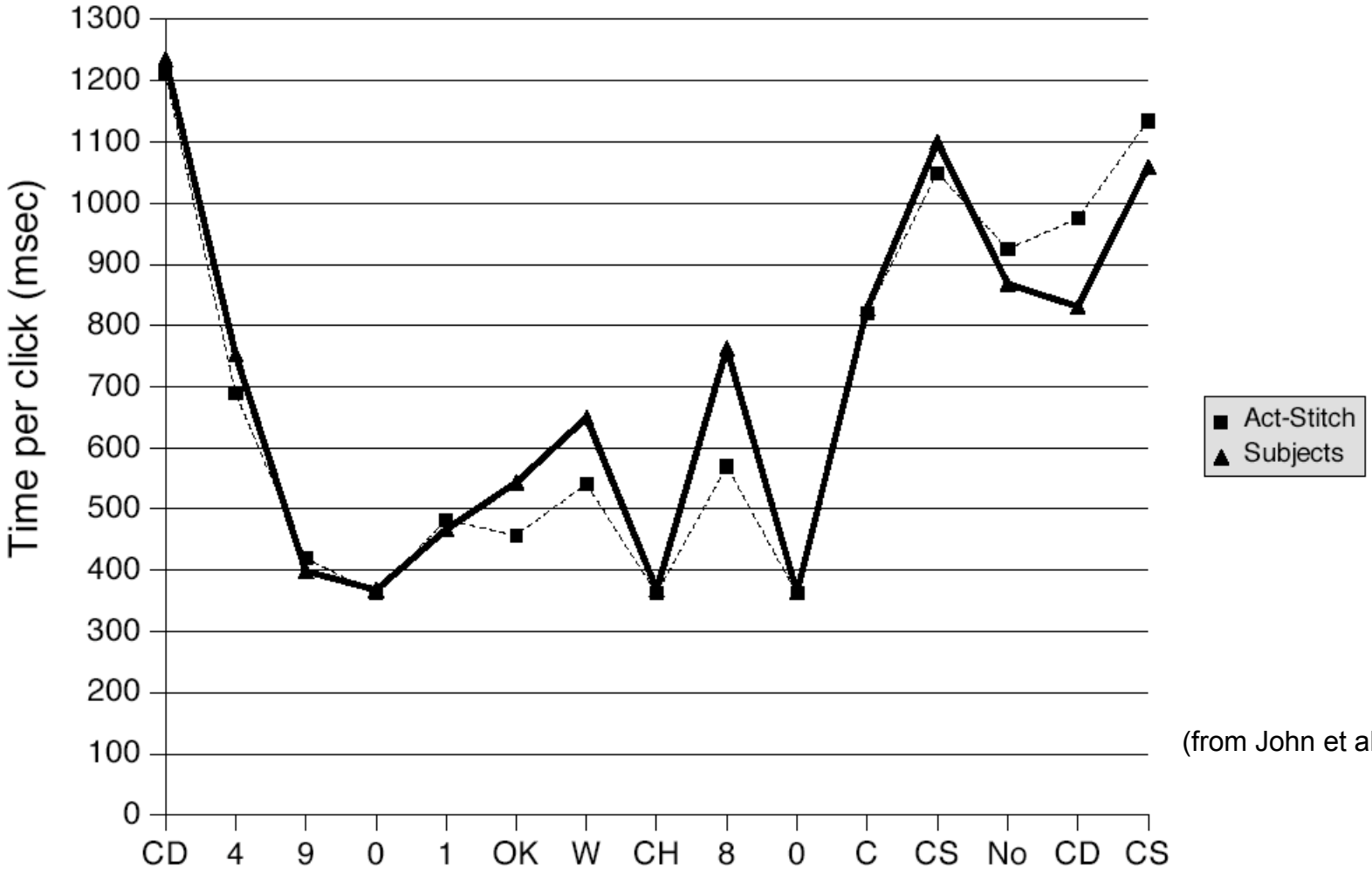
vision-action: attend-T2 vision-target: targ2 r-hand-action: click-T1 r-hand-target: targ1	interleaving with correct sequencing and multiple actions and targets

Task 1 - Mouse Clicking

Task 1 Results



Task 1 Results

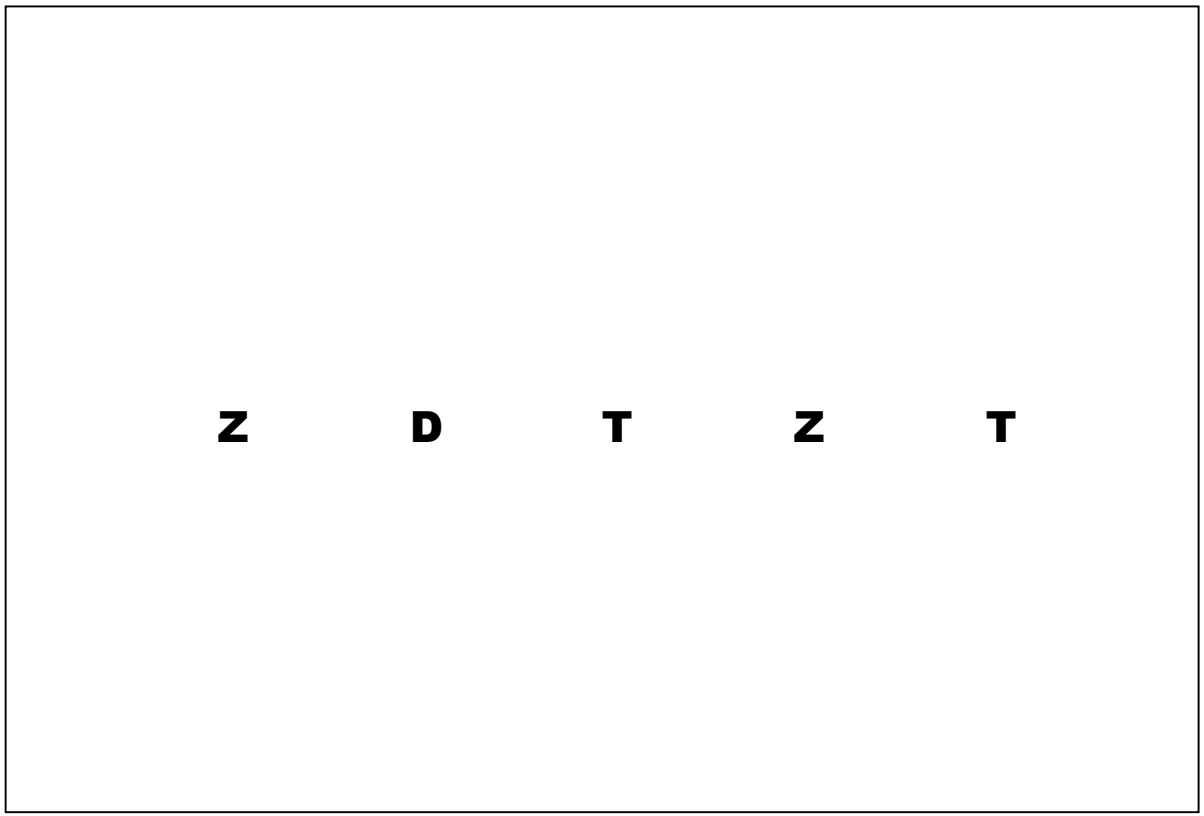


(from John et al., 2002)

Task 1 Conclusions

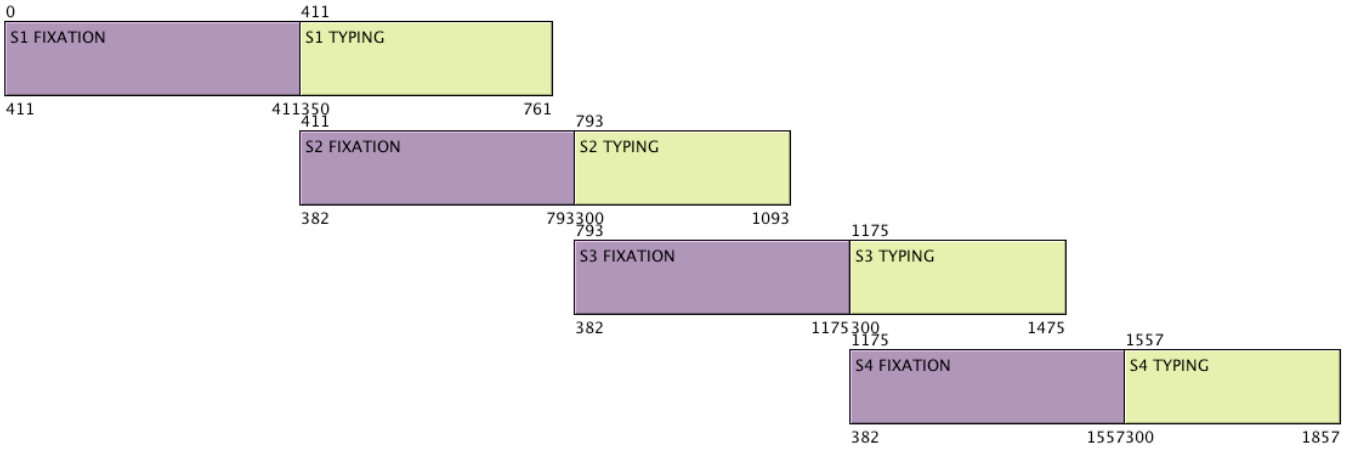
- The quick mouse clicks predicted by ACT-Stitch are empirically validated
- The speed of well-practiced behavior is due to interleaving eye movements

Task 2 - Eye Movements



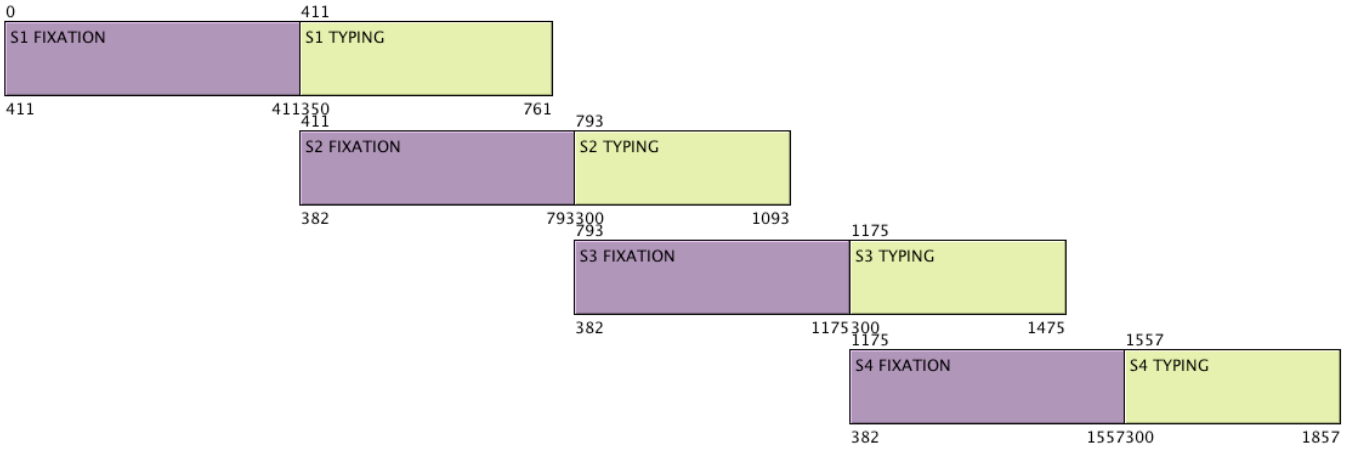
Task 2 Results

ACT-Stitch prediction:

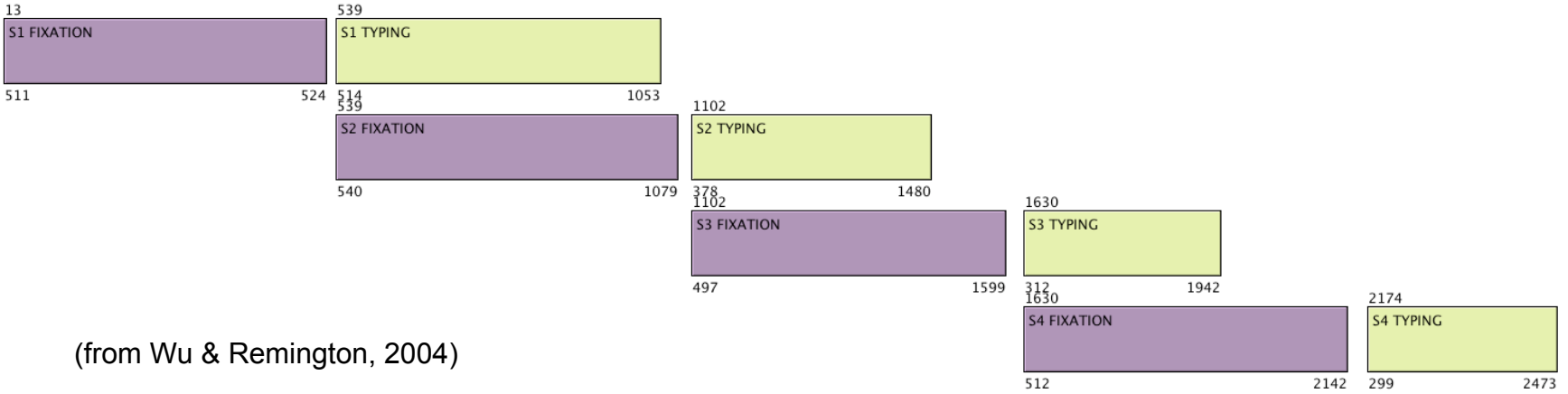


Task 2 Results

ACT-Stitch prediction:



Subject data:



(from Wu & Remington, 2004)

Task 2 Conclusions

- The interleaving eye movement predicted by ACT-Stitch is empirically validated

General Conclusions

- ACT-Stitch is an easy way to make zero-parameter predictions of complex behavior
- The parallel control structure of ACT-Stitch allows the prediction of interleaving eye movements
- Interleaving eye movements can explain the speed of well-practiced behavior

Future Directions

- New templates that wait for external events will allow the modeling of more interactive behavior
- Combining ACT-Stitch's parallel control structure with ACT-R's learning theory will allow prediction from novice instruction reading to expert interleaving

References

John, B. E., Vera, A. H., Matessa, M., Freed, M., & Remington, R. (2002) Automating CPM-GOMS. In Proceedings of CHI'02: Conference on Human Factors in Computing Systems. ACM, New York.

Matessa, M., Vera, A., John, B., Remington, R., & Freed, M. (2002). Reusable Templates in Human Performance Modeling. In Proceedings of the Twenty-fourth Conference of the Cognitive Science Society.

Matessa, M. (2004). Anticipatory Eye Movements in Interleaving Templates of Human Behavior. In Proceedings of the Fifth International Conference on Cognitive Modeling.

Salvucci, D. D., & Lee., F. J. (2003). Simple cognitive modeling in a complex cognitive architecture. Human Factors in Computing Systems: CHI 2003 Conference Proceedings. New York: ACM Press.